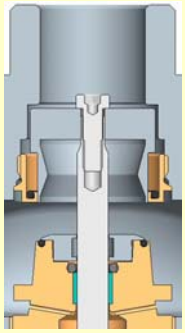
Sketch:	Title:
	Double sealing moving seat as a pressure relieved valve cone
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Keywords:	Abstract:
Pressure relief, pressure relieved cone, valve cone, moving seat, dynamic O-ring	Basic idea is to get as much pressure relieved valve cone as possible and at the same time eliminate dynamic O-rings usually needed for sealing between two valve chambers with different pressures. The absenece of a dynamic O-ring also reduces demand for surface finish and has a positive impact on hysteresis in differential pressure regulators.
References:	HKL project
Restrictions, advices:	Tolerance stacking analysis on an assembly of valve's moving seat and fixed cone must be made to ensure a proper performance of double sealing.

1 BACKGROUND

Conventionally three solutions for a pressure relief of valve cones are used – a piston, a bellows and a diaphragm. There is also a fourth principle for achieving a pressure relieved control element which reverses the function of valve seat and valve cone – so called moving seat. In this case valve's cone (the component that defines valve's characteristic) is fixed and the valve's seat is moving. Conventionally, in a case of a piston or a moving seat there is a dynamic O-ring used to seal between different valve chambers (different pressures). However this means a limited lifetime due to an O-ring wear and in case of use in a differential pressure regulator an increase of hysteresis which will most likely only worsen in time. Both phenomena are highly dependent on a surface finish of the moving element that is in contact with the O-ring. This puts a high demand on maintaining a very good surface quality and also suitable grease must be used lubricate the dynamic O-ring.

2 WORK PRINCIPLE

The basic idea of a moving seat is eliminating sometimes difficult and time consuming procedure of finding the optimal spot (or spots) for taking the pressure for the pressure relief piston, bellows or membrane. However the seat must be properly designed to ensure as small forces on it (due to pressure difference) as possible.

To maintan a certain valve opening, the sum of all forces acting on a valve's stem must be 0.

Control valve example (one end of a spindle is at atmospheric pressure p_{ATM}):

$$-F_{MS} - F_S + F_{MA} = 0$$

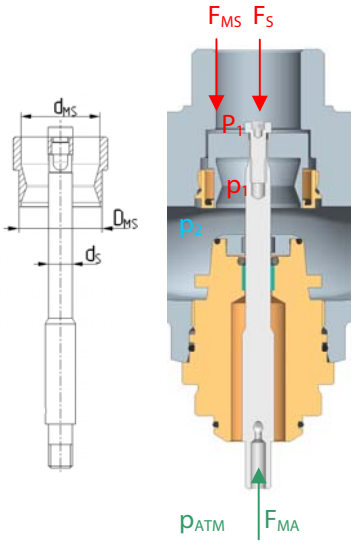
The force that a motor actuator (MA) will have to maintain to keep the valve (in this case) open is:

$$F_{MA} = F_{MS} + F_S \qquad \text{force of a motor actuator}$$

where:

$$F_{MS} = (p_1 - p_2) \cdot \frac{\pi}{4} \cdot \left(D_{MS}^2 - d_{MS}^2\right) \qquad \text{force on a moving seat}$$

$$F_S = p_1 \cdot \frac{\pi}{4} \cdot d_S^2 \qquad \text{force on a spindle}$$



Differential pressure regulator example:

$$-F_{MS} - F_S - F_M + F_{SS} = 0$$

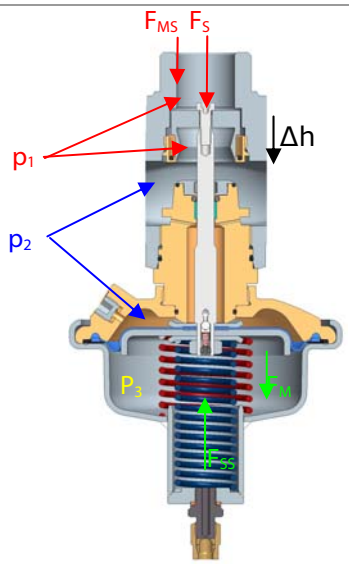
where:

$$F_{MS} = (p_1 - p_2) \cdot \frac{\pi}{4} \cdot (D_{MS}^2 - d_{MS}^2)$$ force on a moving seat

$$F_S = (p_1 - p_3) \cdot \frac{\pi}{4} \cdot d_S^2$$ force on a spindle

$$F_M = (p_2 - p_3) \cdot \frac{\pi}{4} \cdot d_W^2$$ force on a membrane

$$F_{SS} = F_{SS,0} + k \cdot \Delta h = k \cdot (x_0 + \Delta h)$$ setting spring force



From the above equations one can calculate the needed setting spring to maintain a desired pressure diffrence over, for example, a control valve.

$$F_{SS} = F_{MS} + F_S + F_M$$

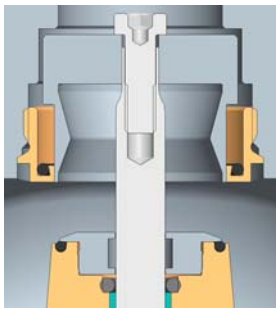
Note that the forces on a moving seat and the spindle increase as the diffrential pressure regulator takes over more pressure pressure difference ($p_1 - p_2$) to maintain a constant pressure difference over the control valve ($p_2 - p_3$). Therefore in order to obtain as good pressure relief (and consequently a pressure independent regulator or in the first example control valve) as possible:

- use as small diameter of the moving seat's spindle as possible to reduce the force induced by a pressure difference on spindle's cross section
- use as thin wall on the moving seat as possible to reduce the force induced by pressure difference on its cross section

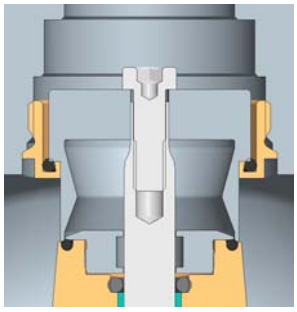
3 BASIC DESIGN

The idea here is upgrading the moving seat solution by eliminating a dynamic O-ring and introducing a double sealing. This means that all drawbacks related to use of a dynamic O-ring are eliminated. Double sealing means that the moving seat seals on (fixed) valve's cone and at the same time on the seat's guiding ring. This sealing occurs only when actually needed – that is, when the valve must close – and not all the time as is the case with conventional solution when a dynamic O-ring is used.

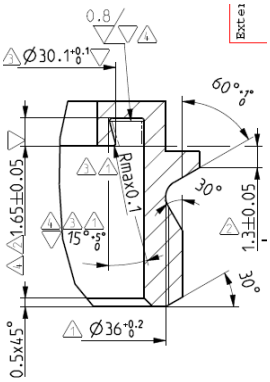
OPENED POSITION



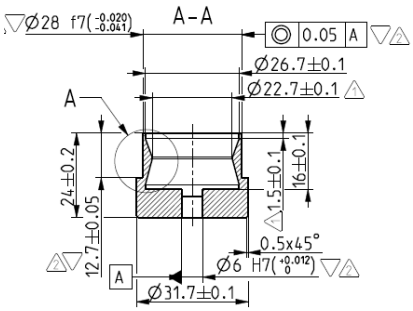
CLOSED POSITION



SEAT GUIDE



MOVING SEAT



4 OTHER RECOMMENDATIONS

With thin walls of a moving seat and no O-ring to dampen the vibration induced by flow of a medium through it, there is a potential risk of developing some kind of noise – most likely whistling. One way to work around this may be to thicken the thin seat walls in a proper place to avoid increasing the cross section on which the pressure difference over the seat can act. By thickening the seat's walls one can change own frequency of the seat (so it moves out of a normal hearing range if vibrations of the seat occur), reduce its amplitude or influence the flow in a way it can not induce the vibrations in the first place.

Another important matter, regarding the design, is tolerance stacking analysis on an assembly of valve's moving seat and fixed cone to ensure a proper performance of double sealing.